BNWL-1544
UC-70

ION EXCHANGE TREATMENT
OF B PLANT PROCESS CONDENSATE

B. W. Mercer and J. G. Adams

November 1970

AEC RESEARCH &
DEVELOPMENT REPORT

BNWL-1544

BATTELLE

NORTHWEST

BATTELLE MEMORIAL INSTITUTE

PACIFIC NORTHWEST LABORATORIES

3000 STEVENS DRIVE, P.O. BOX 998, RICHLAND, WASHINGTON 99352

NOTICE

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Atomic Energy Commission, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

PACIFIC NORTHWEST LABORATORY

RICHLAND, WASHINGTON

operated by

BATTELLE MEMORIAL INSTITUTE

for the

UNITED STATES ATOMIC ENERGY COMMISSION UNDER CONTRACT AT(45-1)-1830

3 3679 00061 7755

BNWL-1544
UC-70, Waste
Disposal
and Processing

ION EXCHANGE TREATMENT
OF B PLANT PROCESS CONDENSATE

B. W. Mercer and J. G. Adams

Water and Land Resources Department
Environmental and Life Sciences Division

November 1970

BATTELLE MEMORIAL INSTITUTE
PACIFIC NORTHWEST LABORATORIES
RICHLAND, WASHINGTON 99352

Printed in the United States of America
Available from
National Technical Information Service
National Bureau of Standards,
U.S. Department of Commerce
Springfield, Virginia 22151
Price: Printed Copy \$3.00; Microfiche \$0.65

ION EXCHANGE TREATMENT
OF B PLANT PROCESS CONDENSATE

B. W. Mercer and J. G. Adams

ABSTRACT

Laboratory experiments were conducted to evaluate ion exchange treatment of B Plant process condensate. Ion exchange was found to be effective for removing the principal radionuclides providing the condensate was steam stripped to remove ammonia. The cation and anion exchange resins must be used in the H^+ and OH^- form, respectively, for satisfactory removal of all radionuclides. The presence of Ca^{+2} and Mg^{+2} in the condensate limits the volume put through the ion exchange beds to ^{137}Cs breakthrough if the ammonia is reduced to near 0 mg/liter.

•

•

•

•

•

•

•

•

•

•

TABLE OF CONTENTS

FIGURES	vii
TABLES	viii
INTRODUCTION.	1
SUMMARY AND CONCLUSIONS	2
METHODS OF INVESTIGATION.	3
DISCUSSION	5
TREATMENT PROCESS	13
REFERENCES	24

FIGURES

1	Breakthrough Curves for the Principal Radionuclides in Steam Stripped BCP Put Through Cation and Anion Exchange Columns	15
2	Breakthrough Curves for the Principal Radionuclides in Steam Stripped BCP Put Through a Cation Exchange Column in Water Recycle Run 1	16
3	Breakthrough Curves for the Principal Radionuclides in Steam Stripped BCP Put Through Cation and Anion Exchange Columns in Water Recycle Run 1	17
4	Breakthrough Curves for the Principal Radionuclides in Steam Stripped BCP Put Through a Cation Exchange Column in Water Recycle Run 2	18
5	Breakthrough Curves for the Principal Radionuclides in Steam Stripped BCP Put Through Cation and Anion Exchange Columns in Water Recycle Run 2	19
6	Breakthrough Curves for the Principal Radionuclides in Steam Stripped BCP Put Through a Cation Exchange Column in Water Recycle Run 3	20
7	Breakthrough Curves for the Principal Radionuclides in Steam Stripped BCP Put Through Cation and Anion Exchange Columns in Water Recycle Run 3	21
8	Elution Curves for Cesium and Strontium from the Cation Column Using 4M Nitric Acid Upflow	22
9	Elution Curves for Ruthenium and Antimony from the Anion Column Using 2M Sodium Hydroxide Upflow	23
10	Flow Diagram	24

TABLES

1	Chemical and Radiochemical Analyses of BCP Samples	4
2	Removal of Ammonia, Organic Carbon, and Inorganic Carbon by Steam Stripping	5
3	Radionuclide Concentrations and Decontamination Factors for an H^+ Based Cation Resin in Series with an OH^- Based Anion Resin Column with Steam Stripped BCP Sampled on 8/27/69	6
4	Radionuclide Concentrations and Decontamination Factors in Series for an H^+ Based Cation Resin and an OH^- Based Anion Resin Column with Steam Stripped BCP Sampled on 9/15/69	7
5	Radionuclide Concentrations and Decontamination Factors for Effluents from NH_4^+ Based Cation Resin and OH^- Based Resin Column in Series with Steam Stripped BCP Sampled on 9/15/69	8
6	Radionuclide Concentrations and Decontamination Factors for Effluents from NH_4^+ Based Cation Resin and OH^- Based Anion Resin Columns in Series with Untreated BCP Sampled on 9/15/70	9

ION EXCHANGE TREATMENT OF B PLANT PROCESS CONDENSATE

B. W. Mercer and J. G. Adams

INTRODUCTION

The low and intermediate level waste treatment program has the objective of providing economical methods for minimizing the release to the environs of radionuclides in liquid wastes. Emphasis is placed on the removal of radionuclides, particularly those with long half lives, by methods more economical than evaporation. One of the more attractive methods for the treatment of low and intermediate level wastes is ion exchange.⁽¹⁾ Under the proper conditions radioactive wastes may be decontaminated at a small fraction of the cost of evaporation. Removal efficiencies exceeding 99% are commonly demonstrated by ion exchange waste treatment processes and removal efficiencies exceeding 99.9% can be achieved in certain instances.⁽²⁾

Considerable research effort has been focused on the removal of ^{137}Cs from radioactive wastes⁽³⁻⁵⁾ using cesium selective zeolites. These zeolites are currently being used to remove ^{137}Cs and other radionuclides from low and intermediate level wastes at Hanford,⁽⁸⁾ Savannah River,⁽¹⁾ and the National Reactor Testing Station.⁽⁹⁾ Cesium selective zeolites are usually not effective for the removal of mixed fission products from wastewaters. These mixtures generally require total anion and cation removal (demineralization) to achieve high decontamination efficiencies. This is best accomplished under acidic conditions (pH, 2-4), although a strong acid cation resin in the H^+ form is often effective. The breakthrough of radioactivity from ion exchange beds is governed by the concentration of salts in the wastewaters which replace the H^+ and OH^- of the cation and anion exchange beds.

B Plant process condensate (BCP) has been characterized previously and found to consist largely of radioactive cesium, strontium, and cerium in essentially a dilute ammonia solution.⁽⁶⁾ Measurable increase in concentrations of other fission products may be expected in the future.⁽⁷⁾ In order to achieve discharge limits for all radionuclides, total demineralization by cation and anion exchange was deemed necessary. This report concerns a laboratory study of the decontamination of B Plant process condensate by ion exchange.

SUMMARY AND CONCLUSIONS

1. Steam stripping and cation and anion exchange were found effective for reducing the concentration of total beta in B Plant process condensate (BCP) by one to two orders of magnitude. Cation exchange alone is effective for removal of ^{137}Cs , ^{90}Sr , and ^{144}Ce - ^{144}Pr from steam stripped BCP. Anion exchange is needed to reduce the levels of ^{106}Ru and ^{125}Sb , although very little if any removal will be needed in most instances.
2. Ion exchange was not effective for the removal of the principal radionuclides without steam stripping. The concentration of ammonia is too high to attain adequate decontamination factors or volumes processed to breakthrough. The cation and anion exchange resins must be used in the H^+ and OH^- form, respectively, for satisfactory removal of all radionuclides.
3. The presence of hardness (Ca^{+2} and Mg^{+2}) in the BCP appears to be the most likely limiting factor on volume throughput for the cation column to ^{137}Cs breakthrough if the ammonia is reduced to near 0 mg/liter; however the ^{137}Cs breaks through the column ahead of the hardness.
4. Injection of a small amount of acid to the cation column feed will be necessary at times to assure a sufficiently low pH in the cation column for effective removal of ^{90}Sr and rare earth radionuclides.

METHODS OF INVESTIGATION

Ion exchange columns were prepared by packing specified volumes of ion exchange resins in glass tubes with wire screens and/or glass wool at each end to hold the resins in place. Waste solutions were pumped downflow through the columns by means of peristaltic pumps. Regenerant solutions were pumped upflow through the resin columns to minimize radioactivity leakage and more effectively use the regenerants. The volume put through a column is reported in terms of column volume, defined as the volume occupied by the resin including the void spaces. Relatively small resin particles (30 x 50 mesh) were used in the 6 mm diameter column to avoid wall effects. All experiments were conducted at room temperature, which varied between 23 and 30 °C. Strongly acidic and strongly basic ion exchange resins were used in the experiments because of their greater effectiveness for removing radioactivity from wastewaters.

Condensate waste for the study was obtained from the B Plant Fission Products Processing Building. This process condensate arises from the evaporation of waste streams generated by processes for the recovery of fission product ^{137}Cs , ^{90}Sr and selected rare earths. The evaporated waste contains ammonium salts in an alkaline solution which results in ammonia volatilization and subsequent absorption in the condensate. Chemical and radiochemical analyses of BCP samples taken in August and September of 1969 are reported in Table 1.

A steam stripper was fabricated for use in removing ammonia from the BCP. The stripping column consisted of 0.5 in. ceramic Intalox[®] saddles packed in a 2 in. ID glass pipe to a depth of 3 feet. The stripper was operated at a feed rate of 21 ml/min

[®] Trademark of the Norton Company

TABLE 1. Chemical and Radiochemical
Analyses of BCP Samples

<u>Analysis</u>	<u>8/27/69 Sample</u>	<u>9/15/69 Sample</u>
Ammonia, mg/l NH_4	3700	2700
Sodium, mg/l	<2	<2
Carbon, Organic, mg/l	115	45
Carbon, Inorganic, mg/l	795	55
Conductivity, m mohs/cm	7620	2400
Turbidity, JTU	0.10	0.17
pH	9.6	10.2
Total Beta @ 0.3 MeV, $\mu\text{Ci/ml}$	4.9×10^{-3}	1.1×10^{-3}
Total Sr @ ^{90}Sr , $\mu\text{Ci/ml}$	1.5×10^{-5}	5.0×10^{-5}
^{90}Sr , $\mu\text{Ci/ml}$	1.1×10^{-5}	1.7×10^{-5}
^{144}Ce - ^{144}Pr , $\mu\text{Ci/ml}$	2.9×10^{-4}	4.6×10^{-4}
^{106}Ru , $\mu\text{Ci/ml}$	6.6×10^{-5}	3.3×10^{-5}
^{137}Cs , $\mu\text{Ci/ml}$	1.9×10^{-3}	3.9×10^{-4}
^{134}Cs , $\mu\text{Ci/ml}$	5.2×10^{-5}	6.2×10^{-6}
^{95}Zr , $\mu\text{Ci/ml}$	2.0×10^{-4}	8.1×10^{-6}
^{95}Nb , $\mu\text{Ci/ml}$	1.0×10^{-4}	3.3×10^{-5}

with a 13% boil-off rate which removed an average 96.6 of the ammonia from the condensate. The stripper was also effective in removing both organic carbon and inorganic carbon (CO_2) from the BCP as illustrated in Table 2.

TABLE 2. Removal of Ammonia, Organic Carbon, and Inorganic Carbon by Steam Stripping

Analysis	8/27/69 Sample		9/15/69 Sample	
	Feed, mg/l	Effluent, mg/l	Feed, mg/l	Effluent, mg/l
NH ₃	3700	15	2700	13
Organic Carbon	115	--	45	13
Inorganic Carbon	795	10	55	4.5
pH	9.6	8.1	10.2	9.0

DISCUSSION

Initial laboratory studies were conducted with BCP samples and a strong acid cation exchange resin column in series with a strong base anion exchange resin column to determine the decontamination factors (DF) obtainable under a variety of conditions. Both steam stripped and non-steam stripped BCP was employed with the cation exchange resin in either the H⁺ form or the NH₄⁺ form. The anion exchange resin was used in the OH⁻ form only. Two liters of BCP feed were pumped through both the cation column and anion column in series before a 1 liter sample of effluent was removed first from the cation column and then from the anion column. Another liter was pumped through both columns and the effluent sampling repeated. The radio-nuclide concentrations in the influent and effluent samples are listed in Tables 3, 4, 5 and 6 along with decontamination factors.

The largest decontamination factors are shown in Tables 3 and 4, where a H⁺ from cation resin column was used in series with an OH⁻ form anion resin column with steam stripped BCP. The results are in agreement with ion exchange studies conducted with other wastewasters where H⁺ form cation exchange resins

TABLE 3. Radionuclide Concentrations and Decontamination Factors
for an H^+ Based Cation Resin in Series with an OH^- Based
Anion Resin Column with Steam Stripped BCP Sampled
on 8/27/69

Stream	Column Volumes	Total Beta		Total Sr		^{137}Cs		^{106}Ru		$^{144}\text{Ce}-^{144}\text{Pr}$	
		Conc. $\mu\text{Ci}/\text{m}\ell$	DF	Conc. $\mu\text{Ci}/\text{m}\ell$	DF	Conc. $\mu\text{Ci}/\text{m}\ell$	DF	Conc. $\mu\text{Ci}/\text{m}\ell$	DF	Conc. $\mu\text{Ci}/\text{m}\ell$	DF
Influent		3300		5.6		1900		36		<2	
Cation Effluent	83	24	140	0.012	470	<0.18	>10,000	8.8	4		
Anion Effluent	83	1.5	2200	0.018	310	0.10	19,000	<0.64	>56		
Cation Effluent	139	25	130	0.028	200	<0.14	>13,000	8.5	4		
Anion Effluent	139	5.6	590	0.051	110	0.16	12,000	1.6	23		

Resin Column Dimensions 1.9 in. diam, 12.7 in. high

Resin Column Volume 36 cm^3

Flow Rate 30 column volumes/hr

Ammonia Concentration 15 mg/ℓ NH_3

Cation Resin. Dowex 50, H^+ form

Anion Resin Dowex 1, OH^- form

TABLE 4. Radionuclide Concentrations and Decontamination Factors
in Series for an H⁺ Based Cation Resin and an OH⁻ Based
Anion Resin Column with Steam Stripped BCP Sampled on 9/15/69

Stream	Column Volumes	Total Beta		Total Sr		¹³⁷ Cs		¹⁰⁶ Ru		¹⁴⁴ Ce- ¹⁴⁴ Pr	
		Conc. μCi/ml	DF	Conc. μCi/ml	DF	Conc. μCi/ml	DF	Conc. μCi/ml	DF	Conc. μCi/ml	DF
Influent		1000		39		430		27		<15	
Cation Effluent	83	53	19	0.084	460	0.23	1900	9.6	2.8		
Anion Effluent	83	4.4	230	0.082	480	0.16	2700	0.53	52		
Cation Effluent	139	43	23	0.079	490	0.21	2100	8.2	3.3		
Anion Effluent	139	3.2	310	<0.046	>850	0.15	2900	<0.6	>42		

Resin Column Dimensions 1.9 cm diam, 12.7 cm high

Resin Column Volume 36 cm³

Flow Rate 30 column volumes/hr

Ammonia Concentration 13 mg/l NH₃

Cation Resin. Dowex 50, H⁺ form

Anion Resin Dowex 1, OH⁻ form

TABLE 5. Radionuclide Concentrations and Decontamination Factors for Effluents from NH_4^+ Based Cation Resin and OH^- Based Resin Column in Series with Steam Stripped BCP Sampled on 9/15/69

Stream	Column Volumes	Total Beta		Total Sr		^{137}Cs		^{106}Ru		^{144}Ce - ^{144}Pr	
		Conc. $\mu\text{Ci}/\text{m}\ell$	DF	Conc. $\mu\text{Ci}/\text{m}\ell$	DF	Conc. $\mu\text{Ci}/\text{m}\ell$	DF	Conc. $\mu\text{Ci}/\text{m}\ell$	DF	Conc. $\mu\text{Ci}/\text{m}\ell$	DF
Influent		1000		39		430		27		240	
Cation Effluent	83	290	3.3	0.34	120	1.1	390	16	1.7	170	1.4
Anion Effluent	83	98	10	0.19	210	0.81	530	2.1	13	66	3.6
Cation Effluent	139	300	3.3	0.24	160	1.2	360	20	1.4	180	1.3
Anion Effluent	139	210	4.8			1.4	310	3.5	7.7	150	1.6

Resin Column Dimensions 1.9 cm diam, 12.7 cm high

Resin Column Volume 36 cm^3

Ammonia Concentration 13 mg/ℓ NH_3

Cation Resin. Dowex 50, NH_4^+ form

Anion Resin Dowex 1, OH^- form

Flow Rate 30 column volumes/hr

TABLE 6. Radionuclide Concentrations and Decontamination Factors for Effluents from NH_4^+ Based Cation Resin and OH^- Based Anion Resin Columns in Series with Untreated BCP Sampled on 9/15/70

Stream	Column Volumes	Total Beta		Total Sr		^{137}Cs		^{106}Ru		$^{144}\text{Ce}-^{144}\text{Pr}$	
		Conc. $\mu\text{Ci}/\text{mL}$	DF	Conc. $\mu\text{Ci}/\text{mL}$	DF	Conc. $\mu\text{Ci}/\text{mL}$	DF	Conc. $\mu\text{Ci}/\text{mL}$	DF	Conc. $\mu\text{Ci}/\text{mL}$	DF
Influent		1200		38		380		270		220	
Cation Effluent	83	390	3.1	0.57	67	3.4	110	270	1	240	1
Anion Effluent	83	250	4.8	0.43	88	5.0	77	85	3.2	180	1.2
Cation Effluent	139	500	2.4	0.64	59	50	7.7	290	1	220	1
Anion Effluent	139	790	1.4	0.64	59	240	1.6	180	1.5	210	1

Resin Column Dimensions 1.9 cm diam, 12.7 cm high

Resin Column Volume 36 cm^3

Flow Rate 30 column volumes/hr

Ammonia Concentration $2700 \text{ mg/L } \text{NH}_3$

Cation Resin Dowex 50, NH_4^+ form

Anion Resin Dowex 1, OH^- form

performed better than other ionic forms for the cation exchange resins.⁽¹⁰⁾ The use of the H^+ form of a cation exchange resin lowers the pH of the liquid in the cation column thereby inducing greater uptake of the radioactivity.⁽¹¹⁾ Rare earth fission products, in particular, are poorly removed from neutral to alkaline solutions by ion exchange. The results given in Table 5 reveals the effect of the relatively high ammonia concentration in non-steam stripped BCP on the DFs obtainable by ion exchange.

The decrease of total beta DFs with increasing column volumes is largely the result of ^{137}Cs breaking through the cation exchange resin after 139 column volumes. The use of H^+ cation resin with non-steamstripped BCP is impractical due to (1) gassing in the resin column from acidification of carbonates in the BCP and (2) the quick exhaustion of the resin by the high concentration of ammonia present.

The results in Tables 3 and 4 indicated sufficient uptake of radioactivity from steam stripped BCP by cation and anion exchange with H^+ and OH^- , respectively, to warrant further investigation with long term column runs. The results of the first extended run are illustrated in Figure 1. The initial total beta and ^{137}Cs DFs exceeded 10^3 and breakthrough above discharge limits occurred at 1800 column volumes. Strontium removal continued well past the ^{137}Cs breakthrough. On the basis of the NH_4^+ concentration, cesium breakthrough should not have occurred prior to 5000 column volumes. Further analysis of the steam stripped BCP used in the first extended runs disclosed a hardness value of 49 mg/liter or $CaCO_3$ or 1×10^{-3} equivalents per liter. At an approximate ion exchange capacity of 2 equivalents per liter of resin, hardness breakthrough near 2000 column volumes is expected. Cesium breakthrough occurs just ahead of hardness breakthrough with sulfonated polystyrene-divinylbenzene cation exchange resins. It may be noted in

Figure 1 that the ^{137}Cs and total beta breakthrough exceeds 100% from about 2000 to 3000 column volumes throughput. This results from sorption of the ^{137}Cs in a band preceding that of Ca^{+2} and Mg^{+2} followed by elution of the ^{137}Cs by the spreading band of sorbed Ca^{+2} and Mg^{+2} . The presence of hardness ions in the BCP results from the addition of a small amount of raw water into this condensate waste stream.

Further extended column runs were conducted to determine the DFs and breakthrough after regeneration of the resin columns. A column of activated carbon, in series after the anion column, was included for ^{106}Ru and ^{60}Co removal, if present in the BCP. The resin and carbon columns were regenerated in accordance with the water recycle process proposed by the Oak Ridge National Laboratory⁽¹²⁾ (6 column volumes of 4M HNO_3 to regenerate the cation column, 8 column volumes of 2M NaOH to regenerate the anion column, and 4 column volumes of 0.5M HNO_3 to regenerate the carbon column). Figures 2, 4, and 6 illustrate the influent and cation effluent concentration for the three runs. Figures 3, 5, and 7 illustrate the influent and effluent concentrations for the cation and anion columns in series. The second run was terminated after 4100 column volumes because of gassing in the cation exchange bed. The gassing is believed to have been caused by high room temperatures during a period of warm weather (feed became supersaturated with air).

Cesium and strontium exist predominantly as cations and are removed to a large extent on the cation exchange column. Cesium breakthrough from the cation column began at 3000 column volumes (Figures 2 and 6) and reached 50% breakthrough at 6000 column volumes. The hardness value of the wastewater in these runs was 11 mg/liter as CaCO_3 or about 20% of that in Figure 1. No strontium breakthrough occurred in the water recycle runs illustrated in Figures 2 through 7; however, strontium DFs varied between 5 and 20, which is considerably less than earlier runs. It is believed that the lower cationic concentrations of

steam stripped BCP used in the water recycle runs prevented the cation exchange resin from lowering the pH. This resulted in a loss of efficiency and less uptake of strontium. Due to a lack of buffer in the samples, pH measurements taken several weeks after the experiments were conducted are not considered reliable. To assure slightly acidic conditions in the cation exchange columns, injection of acid into the feed to the column is considered necessary at times to maintain adequate DFs for strontium and rare earths.

Ruthenium appears to be present in both cationic and anionic forms whereas antimony is present only in the anionic form. Breakthrough of the ruthenium and antimony occurred simultaneously from the anion column except for the final run illustrated in Figure 7, where no uptake of antimony occurred. The cause for no antimony sorption in the final run is unknown. The reported antimony DFs by anion and cation exchange with ORNL low level wastes⁽¹²⁾ is 100 as compared to 0-25 for this study. The character of the ORNL waste is significantly different than that of steam stripped BCP, since the former contains considerably more dissolved electrolytes. Hardness breakthrough occurred at 700 column volumes with the ORNL waste, which would signify some advantage due to a lower pH in the cation column than would be obtained with BCP.

Cesium and strontium elution curves using 4M HNO_3 are illustrated in Figure 8 for the cation exchange column. Ruthenium and antimony elution curves using 2M NaOH are illustrated in Figure 9 for the anion exchange column. The activated carbon column was regenerated with 0.5M HNO_3 and very little ^{60}Co was detected (1×10^{-5} $\mu\text{Ci/ml}$). Ruthenium-106 was also detected in the carbon column regenerant but at a level of only 25 times the influent which also indicates low adsorption. No significant sorption was noted across the carbon column during the loading cycles. Cobalt-60 was not detectable by a gamma scan of the feed.

The elution curves in Figure 8 show that strontium and cesium elution was complete with 6 column volumes of 4M HNO_3 . The elution was about 90% complete at 3 column volumes. The final 3 column volumes of regenerant with its low concentrations of cesium and strontium are saved for use as the initial regenerant in the next cycle to minimize the amount of acid used. This split regenerant method is also used with the 2M NaOH anion regenerant. The low C/C_0 values shown in Figure 9 for ruthenium and antimony result from early breakthrough relative to cesium and stontium. Further, a portion of the ruthenium and trace antimony was desorbed as the band of sorbed macro anion proceeded down the anion exchange column.

TREATMENT PROCESS

A flow diagram for the combined steam stripping-ion exchange treatment process recommended for decontaminating BCP is given in Figure 10. A possible option not included in the flow diagram is a vacuum deaerator to remove CO_2 from the cation column effluent. Removal of the CO_2 will increase the length of the service cycle of the anion column which would be particularly important if a significant amount of nitric acid is necessary to maintain a low pH in the cation column. The anion column is twice as large as the cation column to account for the lower exchange capacity of the anion exchange resin. Both columns can be regenerated at the same time to minimize downtime.

A multimedia sand filter is included as a precautionary measure. Some particulate and colored impurities, which may have come from the waste tanks were noted in the laboratory studies and should be removed prior to ion exchange. The multimedia

filter is composed of granular anthracite coal, silica sand, and garnet sand graded coarse to fine for in-depth filtration. Recommended filter flow rates are 5 to 7.5 gpm/ft² and a backwash rate of 15 gpm/ft² with cool water. Backwash with warm water will require higher flow rates.

Macroreticular ion exchange resins (such as Amberlite IR-200) recommended for use due to the greater fouling resistance and durability of this type of resin. The optimum pH range for the feed to the cation exchange column will be 3.5 to 6. The ratio of 60% nitric acid to steam stripped BCP feed will vary from 0 to 10⁻³.

FIGURE 1. Breakthrough Curves for the Principal Radionuclides in Steam Stripped BCP Put Through Cation and Anion Exchange Columns

Resin Column Dimensions . . . 6 mm diam, 21 cm high
 Resin Column Volume 6 cm^3
 Flow Rate 30 column volumes/hr
 Ammonia Concentration 1 mg/l
 Cation Exchange Resin Amberlite IR200, H^+ form
 Anion Exchange Resin. Dowex 1 x 8, OH^- form

FIGURE 2. Breakthrough Curves for the Principal Radionuclides in Steam Stripped BCP Put Through a Cation Exchange Column in Water Recycle Run 1

Resin Column Dimensions . . . 6 mm diam, 21 cm high
 Resin Column Volume 6 cm^3
 Flow Rate 30 column volumes/hr
 Ammonia Concentration 3 mg/liter
 Cation Exchange Resin Dowex 50 x 8, H^+ form
 Anion Exchange Resin. Dowex 1 x 8, OH^- form

FIGURE 3. Breakthrough Curves for the Principal Radionuclides in Steam Stripped BCP Put Through Cation and Anion Exchange Columns in Water Recycle Run 1

Resin Column Dimensions . . . 6 mm diam, 21 cm high
 Resin Column Volume 6 cm^3
 Flow Rate 30 column volumes/hr
 Ammonia Concentration 3 mg/liter
 Cation Exchange Resin Dowex 50 x 8, H^+ form
 Anion Exchange Resin. Dowex 1 x 8, OH^- form

FIGURE 4. Breakthrough Curves for the Principal Radionuclides in Steam Stripped BCP Put Through a Cation Exchange Column in Water Recycle Run 2

Resin Column Dimensions . . . 6 mm diam, 21 cm high
 Resin Column Volume . . . 6 cm^3
 Flow Rate . . . 30 column volumes/hr
 Ammonia Concentration . . . 3 mg/liter
 Cation Exchange Resin . . . Dowex 50 x 8, H^+ form
 Anion Exchange Resin. . . Dowex 1 x 8, OH^- form

FIGURE 5. Breakthrough Curves for the Principal Radionuclides in Steam Stripped BCP Put Through Cation and Anion Exchange Columns in Water Recycle Run 2

Resin Column Dimensions . . . 6 mm diam, 21 cm high
 Resin Column Volume 6 cm^3
 Flow Rate 30 column volumes/hr
 Ammonia Concentration 3 mg/liter
 Cation Exchange Resin Dowex 50 x 8, H^+ form
 Anion Exchange Resin. Dowex 1 x 8, OH^- form

FIGURE 6. Breakthrough Curves for the Principal Radionuclides in Steam Stripped BCP Put Through a Cation Exchange Column in Water Recycle Run 3

Resin Column Dimensions . . . 6 mm₃ diam, 21 cm high
 Resin Column Volume 6 cm³
 Flow Rate 30 column volumes/hr
 Ammonia Concentration 3 mg/liter
 Cation Exchange Resin Dowex 50 x 8, H⁺ form
 Anion Exchange Resin. Dowex 1 x 8, OH⁻ form

FIGURE 8. Elution Curves for Cesium and Strontium from the Cation Column Using 4M Nitric Acid Upflow

FIGURE 9. Elution Curves for Ruthenium and Antimony from the Anion Column Using 2M Sodium Hydroxide Upflow

FIGURE 10. Flow Diagram

REFERENCES

1. L. A. Emelity. Operation and Control of Ion Exchange Processes for Treatment of Radioactive Wastes, Technical Report Series No. 78. International Atomic Energy Agency, Vienna, 1967.
2. B. W. Mercer. Treatment of Radioactive Wastes by Ion Exchange, BNWL-SA-2369. Paper presented at the 66th National American Institute of Chemical Engineers, Portland, Oregon, August 1969.
3. B. W. Mercer. The Decontamination of Condensates Containing Ammonia, HW-71627. Available from National Technical Information Service, Springfield, Virginia, March 1962.
4. B. W. Mercer. Adsorption of Trace Ions from Intermediate Level Radioactive Wastes by Ion Exchange, BNWL-180. Battelle-Northwest, Richland, Washington, January 1966.
5. B. W. Mercer, L. L. Ames, R. G. Parkhurst. Removal of ^{137}Cs from Alkaline Condensate Water, BNWL-829. Battelle-Northwest, Richland, Washington, January 1966.
6. B. W. Mercer. Unpublished Data. Battelle-Northwest, Richland, Washington.
7. G. L. Hanson. Personal Communication. Battelle-Northwest, Richland, Washington, March 1970.
8. C. J. Francis. Personal Communications. Atlantic Richfield Hanford Company, Richland, Washington, September 1970.
9. M. W. Wilding and D. W. Rhodes. Removal of Radioisotopes from Solution with Earth Materials from Eastern Idaho, IDO-14624. Idaho Operations Office, Idaho Falls, November 1964.
10. J. M. Skarpelos. Progress in the Treatment of Radioactive Condensate Waste, HW-79174. Available from National Technical Information Service, Springfield, Virginia, October 1963.
11. H. G. Swope. "Mixed Bed Ion Exchange for the Removal of Radioactivity," J. Am. Water Works Assoc., vol. 49, p. 1085. 1957.
12. W. C. Yee, F. Delora, and W. E. Shockley. Low-Level Radioactive Waste Treatment: The Water Recycle Process, ORNL-4472. Oak Ridge National Laboratory, Oak Ridge, Tennessee, 1970.

DISTRIBUTIONNo. of
CopiesOFFSITE

1	<u>AEC Chicago Patent Group</u> G. H. Lee
177	<u>AEC Division of Technical Information Extension</u>

ONSITE-HANFORD

1	<u>AEC Chicago Patent Group</u> R. K. Sharp (Richland)														
3	<u>AEC Richland Operations Office</u> M. R. Schneller O. J. Elgert (2)														
13	<u>Atlantic Richfield Hanford Company</u> M. D. Alford S. J. Beard J. B. Fecht C. J. Francis W. L. Godfrey G. L. Hanson R. E. Isaacson G. R. Kiel C. G. Oberg L. M. Richards G. L. Ritter R. E. Tomlinson R. E. Van Der Cook														
2	<u>RDT Assistant Director for Pacific Northwest Programs</u>														
40	<u>Battelle-Northwest</u> <table> <tr> <td>L. L. Ames</td> <td>D. E. Olesen</td> </tr> <tr> <td>E. L. Alpen</td> <td>R. C. Routson</td> </tr> <tr> <td>R. E. Burns</td> <td>A. J. Shuckrow</td> </tr> <tr> <td>G. L. Culp</td> <td>C. J. Touhill</td> </tr> <tr> <td>J. J. Fuquay</td> <td>Technical Information Files (5)</td> </tr> <tr> <td>W. A. Haney</td> <td>Technical Publications (2)</td> </tr> <tr> <td>B. W. Mercer (30)</td> <td></td> </tr> </table>	L. L. Ames	D. E. Olesen	E. L. Alpen	R. C. Routson	R. E. Burns	A. J. Shuckrow	G. L. Culp	C. J. Touhill	J. J. Fuquay	Technical Information Files (5)	W. A. Haney	Technical Publications (2)	B. W. Mercer (30)	
L. L. Ames	D. E. Olesen														
E. L. Alpen	R. C. Routson														
R. E. Burns	A. J. Shuckrow														
G. L. Culp	C. J. Touhill														
J. J. Fuquay	Technical Information Files (5)														
W. A. Haney	Technical Publications (2)														
B. W. Mercer (30)															